Piezo-Electric Micro Valve for Atmospheric Descent Sampling

Completed Technology Project (2017 - 2019)

Project Introduction

Gas inlet systems for planetary-probe mass spectrometers (MSs) are required to admit gas at a relatively constant mass-flow despite the probe experiencing many orders of magnitude of ambient pressure change during the descent from vacuum to the terminal measurement altitude. A novel variable conductance valve based on micro-electro-mechanical systems (MEMS) technology, and utilizing a piezo-electric actuator is proposed herein as an ideal solution for such inlet system which can be coupled to an MS of choice for the selected atmospheric descent probe. Our piezo-electric microvalve (PEMV) will build on the heritage of a similar device that was developed at JPL 12 years ago for high-pressure gas micropropulsion applications [1-3], and was specifically optimized for proportional flow control of liquid or gas propellant, with measured He leak rates of 5e-3 sccm at 800 psi in its "normally closed" position. It was tested up to pressure difference of 5e4 Torr and could operate up to 125 degrees C. During static operation it consumed 8mW of power when valve was fully opened. Although never used for flight application or its original purpose, this device exhibited excellent characteristics needed for a constant mass-flow inlet system. Our idea is to slightly modify already proven design of the micropropulsion piezo-electric valve to allow for a fine regulation of a mass flow around the optimal value of 5e-7 TorrL/s in the pressure range of 1e2 - 1e5 Torr. That involves changing the number and dimensions of seat rings and adjustment of the tensile strength of the silicon membrane. After valves being manufactured, we will couple them to the JPL QIT-MS [4] and test their performance in desired pressure-temperature range. The principal investigator will be Jurij Simcic who has a lot of practical lab experience in the field of quadrupole ion trap mass spectrometry, atomic and molecular physics and in designing electromagnetic lenses. He is a cognizant engineer for the QIT-MS for the Spacecraft Atmospheric Monitor (S.A.M.) and working on the Atmospheric Constituent Explorer System (ACES) Homesteader project for the maturation of constant mass flow inlet subsystem. Co-I, Byunghoon Bae is a MEMS expert that has more than 12 years of design, fabrication, and testing experience. He was a Co-I for the MEMS GC/MS PIDDP project, and the PI of NASA SBIR Ph II/II-E projects for the development of a MEMS-GC system for Cabin Air monitoring. He was also the PI of Army STTR Ph I/II projects for Micro-burner Based Flame Ionization Detectors (Micro-FIDs) for Micro-scale Gas GCs, which led to development of a portable "lunch box" micro-GC/FID/TCD detectors. He invented unique electrostatic microvalves that survived more than 46 million cycles. Currently in charge of developing MEMS PC/GC chips for S.A.M. flight project. Second Co-I Choonsup Lee, is also a MEMS Technology expert at JPL and one of the authors of the micropropulsion piezo-electric valve. He has extensive experience in the design and characterization of MEMS-based microsensors and microactuators such as thermal inkjet printheads, force-balanced tunneling microaccelerometers, infrared detectors, silicon microlenses, MEMS-based band-pass filters, microvalves, nanochannels, lateral field emission devices, and other MEMS/NEMS devices. Currently, he is

Piezo-Electric Micro Valve for Atmospheric Descent Sampling

Table of Contents

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

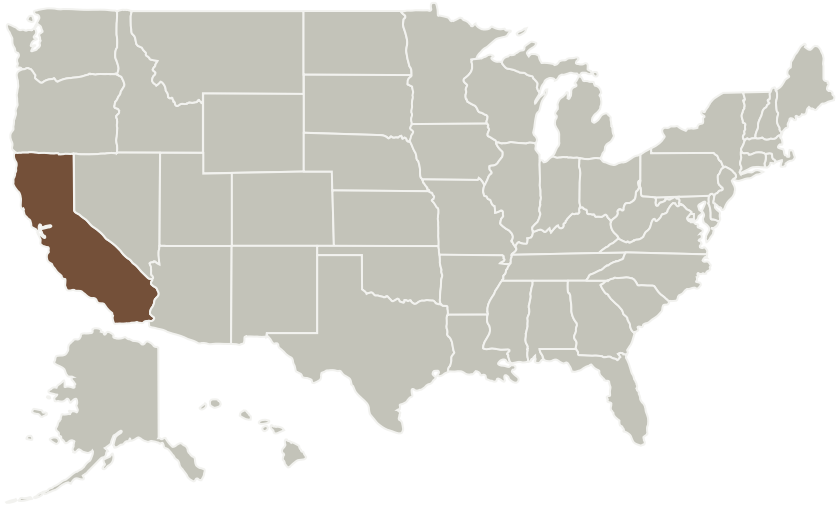
Planetary Instrument Concepts for the Advancement of Solar System Observations

Piezo-Electric Micro Valve for Atmospheric Descent Sampling

Completed Technology Project (2017 - 2019)

working on terrahertz silicon waveguide technology. Third Co-I, Dragan Nikolic has experience in theoretical modeling in plasma, atomic and molecular physics and mass spectrometry calculations. He will be performing computational fluid dynamics (CFD) modeling to optimize the future valve design. [1] Journal of Microelectromechanical Systems, Vol. 13, No. 5, October 2004 [2] Journal of Microelectromechanical Systems, Vol. 15, No. 3, June 2006 [3] Sensors and Materials, Vol.19, No.1 (2007) 001-018 [4] J. Am. Soc. Mass Spectrom. 25(11), (2014)

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
California Institute of Technology(CalTech)	Supporting Organization	Academia	Pasadena, California

Primary U.S. Work Locations
California

Project Management

Program Director:

Carolyn R Mercer

Program Manager:

Haris Riris

Principal Investigator:

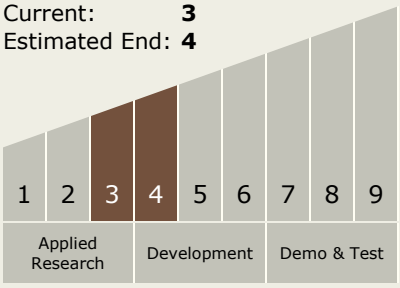
Jurij Simcic

Co-Investigators:

Byunghoon Bae
Karen R Piggee
Choon Sup Lee
Dragan Nikolic

Technology Maturity (TRL)

Start: **3**
Current: **3**
Estimated End: **4**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.3 In-Situ Instruments and Sensors
    - TX08.3.4 Environment Sensors

Piezo-Electric Micro Valve for Atmospheric Descent Sampling

Completed Technology Project (2017 - 2019)

Target Destination

Others Inside the Solar System